PROC. ENTOMOL. SOC. WASH.
84(4), 1982, pp. 729–741

THE MAYFLIES OF NORTHEASTERN MINNESOTA (EPHEMEROPTERA)[1]

T. M. Lager, M. D. Johnson, and W. P. McCafferty

(TML) 636 State Street, Menasha, Wisconsin 54952; (MDJ) P.O. Box 368, Teton Village, Wyoming 83025; (WPM) Department of Entomology, Purdue University, West Lafayette, Indiana 47907.

Abstract.—Analysis of the Ephemeroptora of northeastern Minnesota is based primarily on extensive sampling of larvae from St. Louis and Lake counties. Of 54 identifiable and nominal species, 33 represent new state records. Several notable range extensions are documented. The fauna has a strong affinity with that of eastern Canada; other faunistic relationships are also present. In Minnesota, *Baetis macani bundyae* Lehmkuhl larvae inhabit streams and complete their life cycle one and a half months earlier than larvae in the northern extreme of their range where they inhabit tundra ponds; larvae and adults are similar in size throughout their range.

The Ephemeroptera of Minnesota, especially in the northeastern region, are largely unknown. Although Daggy surveyed the mayfly fauna throughout the state (Daggy, 1938, 1941), he published only a small part of the data (Daggy, 1945). Thomas Say, who accompanied an expedition on the Minnesota and Rainy rivers in the 1820's, was probably the first to report on the state's mayflies (Say, 1823). Burks (1953) documented Minnesota distributions for species found in Illinois. Additional records occur in systematic works (Banks, 1910; Needham et al., 1935; Lewis, 1974; McCafferty, 1975; Edmunds et al., 1976; Berner, 1978; Bednarik and McCafferty, 1979; Morihara and McCafferty, 1979b; Pescador and Berner, *in press*) and in ecological studies of certain species (Waters, 1966; Fremling, 1973; Waters and Crawford, 1973; Hall et al., 1975).

In this paper we document the mayflies of northeastern Minnesota, predict those species likely to occur in the northern region of the state, show faunal relationships to other areas of North America, and discuss the efficacy of factors which may influence the faunal distributions. Larvae were

[1] Part of the Minnesota Regional Copper-Nickel Study, Environmental Quality Board, St. Paul, Minnesota.

extensively sampled in St. Louis and Lake counties located in northeastern Minnesota (Fig. 1) during 1976 and 1977 by the following persons: M. D. Johnson, T. M. Lager, J. L. McCulloch, M. W. Mischuk, and S. N. Williams. Dr. L. Berner identified adult mayflies collected by the late W. V. Balduf, University of Illinois, at Eagles Nest Lake from 1953 to 1959 and made the data available to us. All collections from Eagles Nest Lake are credited to Dr. Balduf.

Description of Study Area

The Precambrian Shield, composed of metamorphic rocks and covered by glacial till and drift, extends into this region (Wright, 1972). The glacial history is evident in the generally flat but locally rugged topography. Many lakes formed in the glacial ice scoured troughs, and numerous streams drain surrounding ridges and lowlands. The Laurentian Divide partitions the area into northern and southern sections (Fig. 1). Streams in the northern section flow north to Hudson Bay via the Nelson System and those in the southern half are a part of the St. Lawrence System (Danks, 1979).

Within the study area, streams up to fourth order occur. The South Kawishiwi River, an atypical fifth order stream, is largely a chain of lakes or lake-like reaches connected by rapids. Most waters in this region are poorly buffered, particularly those in bog drainages. The alkalinity of the South Kawishiwi River, which receives water from most lakes and streams north of the divide ranged from 9 mg/l to 11 mg/l (as $CaCO_3$) (U.S. Geological Survey, 1978). South of the divide the alkalinity of the St. Louis River downstream from the confluence with the Partridge River ranged from 42 mg/l to 59 mg/l.

The forest is a part of the Great Lakes–St. Lawrence forest region, which is a transitional zone between the coniferous and deciduous forests (Scudder, 1979). The region extends from New Brunswick, Canada, to Lake of the Woods on the United States and Canada border about 210 km west of the study area. Portions of northern Wisconsin and Michigan are also included. The dominant vegetation of northeastern Minnesota is characterized by quaking aspen (*Populus tremuloides*) alder (*Alnus rugosa* and *A. crispa*), white pine (*Pinus strobus*), red pine (*P. resinosa*), and white cedar (*Thuja occidentalis*) (Swain, 1980).

The mayfly faunal list is presented systematically by family and alphabetically by genus and species within each family. New state records are indicated with an asterisk (*); new state records that were previously recorded by Daggy (1938; 1941) but unpublished are indicated with two asterisks (**). Collection sites are indicated by numbers corresponding to those listed below and plotted in Fig. 1. Predictions of mayfly species are listed below the lists of collected species. Voucher specimens are deposited at the University of Minnesota, St. Paul, Minnesota.

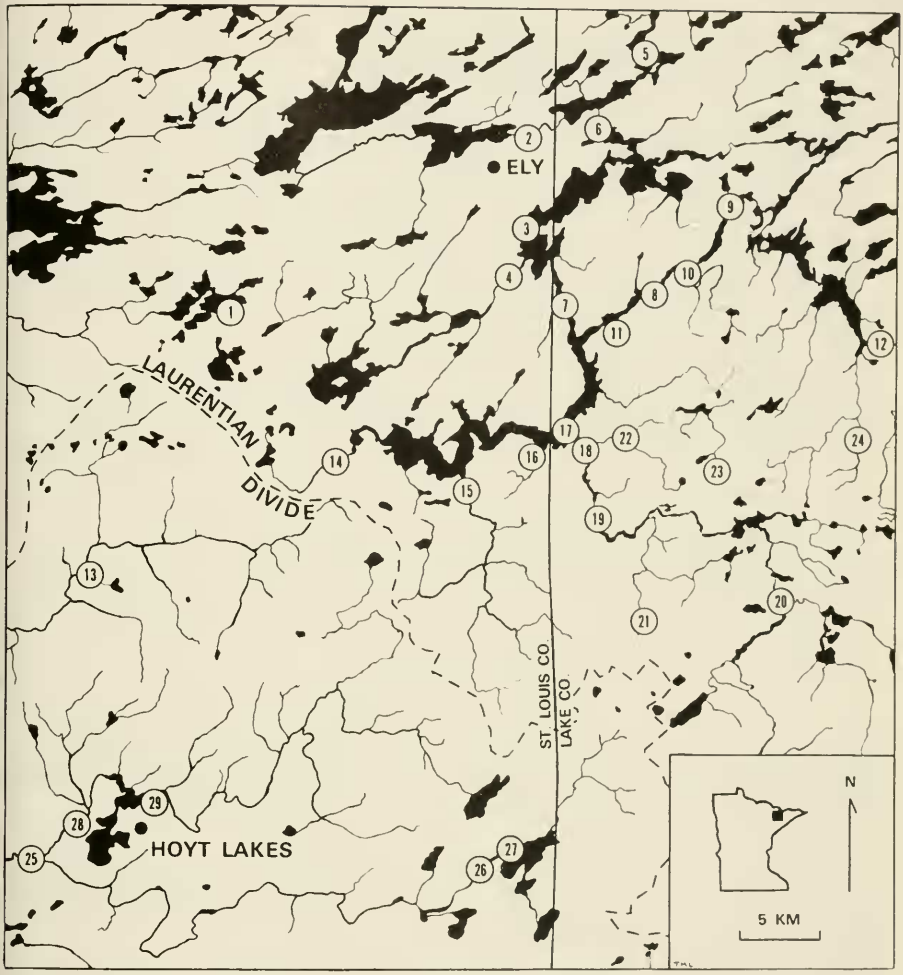

Fig. 1. Study area in St. Louis and Lake counties of northeastern Minnesota with site numbers plotted.

Collection Sites

1. Eagles Nest L., St. Louis Co.: T.62N., R.12W., S.26–28 and 33–35.
2. Shagawa R., St. Louis Co.: T.63N., R.12W., S.26.
3. L. White Iron, St. Louis Co.: T.62N., R.12W., S.11 and 14.
4. Bear Island R., St. Louis Co.: T.62N., R.12W., S.23.

5–9. South Kawishiwi R., Lake Co., 5: T.63N., R.11W., S.3; 6: T.63N., R.11W., S.20; 7: T.62N., R.11W., S.31; 8: T.62N., R.11W., S.23; 9: T.62N., R.10W., S.6.

10. Filson Cr., Lake Co.: T.62N., R.11W., S.24.
11. Two unnamed str., Lake Co.: T.62N., R.11W., S.33.
12. Isabella R., Lake Co.: T.61N., R.9W., S.6.
13. Embarrass R., St. Louis Co.: T.60N., R.15., S.25.
14. Birch R., St. Louis Co.: T.61N., R.13W., S.27.
15. Dunka R., St. Louis Co.: T.60N., R.12W., S.9.
16. An unnamed str., St. Louis Co.: T.61N., R.12W., S.36.
17. Birch L., Lake Co.: T.61N., R.11W., S.30.
18–20. Stony R., Lake Co. 18: T.61N., R.11W., S.30; 19: T.60N., R.11W., S.8; 20: T.60N., R.10W., S.28.
21. Nip Cr., Lake Co.: T.60N., R.11W., S.34.
22. Denley Cr., Lake Co.: T.61N., R.11W., S.28.
23. Nira Cr., Lake Co.: T.61N., R.10W., S.31.
24. Snake Cr., Lake Co.: T.61N., R.9W., S.30.
25–26. St. Louis R., St. Louis Co. 25: T.58N., R.15W., S.22; 26: T.58N., R.12W., S.22.
27. L. Seven Beaver, St. Louis Co.: T.58N., R.12W., S.14.
28. Partridge R., St. Louis Co.: T.58N., R.15W., S.13.
29. L. Colby, St. Louis Co.: T.58N., R. 14W., S.8.

List of Species

Family Siphlonuridae

Genus *Ameletus* Eaton

Ameletus was not taken, however, *A. browni* McDunnough, *A. lineatus* Traver, *A. ludens* Needham, and *A. walleyi* Harper are expected.

Genus *Parameletus* Bengtsson

This genus was not found; expected species are *P. croesus* McDunnough and *P. midas* McDunnough.

Genus *Siphlonurus* Eaton

Siphlonurus alternatus (Say): 5.

Larvae tentatively identified as *S. marshalli* Traver were found; expected species are *S. quebecensis* (Provancher), *S. rapidus* (McDunnough), and *S. typicus* Eaton.

Family Metretopodidae

Genus *Siphloplecton* Clemens

Siphloplecton interlineatum (Walsh): 17, 27.

Expected: *S. basale* (Walker).

Family Baetidae

Genus *Baetis* Leach

Baetis brunneicolor McDunnough: 13, 16, 21.
**Baetis flavistriga* McDunnough: 2, 5, 13, 18, 20, 25, 28.
**Baetis intercalaris* McDunnough: 25, 28.
**Baetis macani bundyae* Lehmkuhl: 11.
**Baetis pygmaeus* (Hagen): 2, 13, 15.
Baetis tricaudatus Dodds: 20, 24.
Expected: *B. frondalis* McDunnough and *B. hageni* Eaton.

Genus *Callibaetis* Eaton

**Callibaetis ferrugineus* (Walsh): 1.
Expected: *C. brevicostatus* Daggy, *C. fluctuans* (Walsh), and *C. skokianus* Needham.

Genus *Centroptilum* Eaton

Larvae were not identifiable to species. Expected species are *C. album* McDunnough, *C. bellum* McDunnough, *C. convexum* Ide, and *C. rufostrigatum* McDunnough.

Genus *Cloeon* Leach

***Cloeon simplex* McDunnough: 1.
Expected: *C. insignificans* McDunnough, *C. mendax* (Walsh), *C. minus* McDunnough, and *C. rubropictum* McDunnough.

Genus *Heterocloeon* McDunnough

***Heterocloeon curiosum* (McDunnough): 8.

Genus *Paracloeodes* Day

Although *P. minutus* (Daggy) inhabits the Mississippi River in southern Minnesota, the lack of large rivers in the study area may prevent its presence.

Genus *Pseudocloeon* Klapalek

Pseudocloeon anoka Daggy: 25.
***Pseudocloeon carolina* Banks: 15.
***Pseudocloeon cingulatum* McDunnough: 15.
***Pseudocloeon dubium* (Walsh): 13, 25.
***Pseudocloeon parvulum* McDunnough: 8, 4.
Expected: *P. punctiventris* McDunnough.

Family Oligoneuriidae

Genus *Isonychia* Eaton

Larvae were not identifiable to species. Expected species are *I. rufa* McDunnough, *I. sadleri* Traver, and *I. sicca* (Walsh).

Family Heptageniidae

Genus *Arthroplea* Bengtsson

**Arthroplea bipunctata* McDunnough: 27, 29.

Genus *Epeorus* Eaton

Larvae were not identifiable to species, however, *E. pleuralis* (Banks) and *E. vitreus* (Walker) are expected.

Genus *Heptagenia* Walsh

This genus was not collected, however, *H. flavescens* (Walsh) and *H. pulla* (Clemens) are expected.

Genus *Leucrocuta* Flowers

Leucrocuta hebe (McDunnough): 9, 15.
Expected: *L. umbratica* (McDunnough).

Genus *Nixe* Flowers

Nixe was not found; *N. lucidipennis* (Clemens) and *N. rusticalis* (McDunnough) are expected.

Genus *Pseudiron* McDunnough

Although *Pseudiron* was not found, *P. centralis* McDunnough may occur here.

Genus *Rhithrogena* Eaton

No larvae were identifiable to species; *R. impersonata* (McDunnough), *R. jejuna* Eaton, and *R. pellucida* Daggy are expected.

Genus *Stenacron* Jensen

***Stenacron candidum* (Traver): 15.
Stenacron interpunctatum (Say): 5, 28.
Stenacron minnetonka (Daggy): 13, 28.

Genus *Stenonema* Traver

Stenonema exiguum Traver: 13, 14, 15, 18, 20.
Stenonema femoratum (Say): 6, 9, 12, 29.

Stenonema integrum (McDunnough): 25.
Stenonema modestum (Banks): 10, 13, 14, 20, 22, 25, 28.
Stenonema pulchellum (Walsh): 9, 13, 28, 20.
Stenonema terminatum (Walsh): 12, 13.
Stenonema vicarium (Walker): 7, 12, 13, 15, 18, 24, 26.
Expected: *S. mediopunctatum* (McDunnough).

Family Leptophlebiidae

Genus *Choroterpes* Eaton

***Choroterpes basalis* (Banks): 20.

Genus *Habrophlebiodes* Ulmer

Although this genus was not collected, *H. americanus* (Banks) is expected.

Genus *Leptophlebia* Westwood

***Leptophlebia cupida* (Say): 1.
Expected: *L. nebulosa* (Walker).

Genus *Paraleptophlebia* Lestage

***Paraleptophlebia guttata* (McDunnough): 15.
***Paraleptophlebia mollis* (Eaton): 15, 20, 25.
***Paraleptophlebia praepedita* (Eaton): 11, 15, 20.
***Paraleptophlebia volitans* (McDunnough): 20.
Expected: *P. adoptiva* (McDunnough), *P. debilis* (Walker), *P. moerens* (McDunnough), *P. ontario* (McDunnough), and *P. strigula* (McDunnough).

Family Potamanthidae

Genus *Potamanthus* Pictet

This genus was not found but *P. myops* (Walsh), *P. rufous* Argo, and *P. verticis* (Say) are expected.

Family Palingeniidae

Genus *Pentagenia* Walsh

Although *P. vittigera* (Walsh) is known from Minnesota, the lack of large rivers with clay banks in the study area evidently precludes its presence.

Family Ephemeridae

Genus *Ephemera* Linnaeus

Ephemera simulans Walker: 15, 20.

Genus *Hexagenia* Walsh

Hexagenia bilineata (Say): 13.
Hexagenia limbata Serville: 1, 3.
Expected: *H. atrocaudata* McDunnough, *H. munda* Eaton, and *H. rigida* McDunnough.

Genus *Litobrancha* McCafferty

**Litobrancha recurvata* (Morgan): 24.

Family Polymitarcyidae

Genus *Ephoron* Williamson

**Ephoron leukon* Williamson: 19.
Expected: *Ephoron album* (Say).

Genus *Tortopus* Needham and Murphy

Tortopus was not collected, although the range of *T. primus* (McDunnough) may encompass northeastern Minnesota, the absence of large rivers having clay banks may preclude its presence.

Family Ephemerellidae

Genus *Attenella* Edmunds

***Attenella attenuata* (McDunnough): 15, 20.

Genus *Dannella* Edmunds

***Dannella simplex* (McDunnough): 15.

Genus *Drunella* Needham

Drunella was not found, however, *D. cornuta* (Morgan), *D. cornutella* (McDunnough), *D. lata* (Morgan), and *D. walkeri* (Eaton) are expected.

Genus *Ephemerella* Walsh

* *Ephemerella invaria* (Walker): 18.
***Ephemerella needhami* McDunnough: 15.
**Ephemerella rotunda* Morgan: 12, 13, 18.
Ephemerella subvaria McDunnough: 5, 7.

Genus *Eurylophella* Tiensuu

***Eurylophella bicolor* (Clemens): 15, 18, 25.
**Eurylophella minimella* (McDunnough): 15.
***Eurylophella temporalis* (McDunnough): 5, 9, 24.
**Eurylophella versimilis* (McDunnough): 29.
Expected: *E. bartoni* (Allen) and *E. lutulenta* (Clemens). *Eurylophella*

funeralis (McDunnough) and *E. prudentalis* (McDunnough) were found in the study area by Daggy (1941).

Genus *Serratella* Edmunds

****Serratella deficiens*** (Morgan): 18, 20, 25.
Serratella serrata (Morgan): 15.
****Serratella sordida*** (McDunnough): 15, 20.

Family Tricorythidae

Genus *Tricorythodes* Ulmer

No larvae were identifiable to species, however, *T. atratus* McDunnough is expected.

Family Caenidae

Genus *Brachycercus* Curtis

Brachycercus larvae were not identifiable to species but *B. lacustris* (Needham) is expected.

Genus *Caenis* Stephens

Caenis simulans McDunnough: 1.
Expected: *C. forcipata* McDunnough, *C. jocosa* McDunnough, *C. latipennis* Banks, and *C. tardata* McDunnough.

Family Baetiscidae

Genus *Baetisca* Walsh

Baetisca laurentina McDunnough: 9, 13, 15, 18, 19, 25.
Expected: *B. lacustris* McDunnough and *B. obesa* (Say).

Faunistics Summary

Fifty-four nominal Ephemeroptera species were confirmed from the study area; 33 are new state records, 20 of which were recorded by Daggy (1938, 1941) but are unpublished. As a result of earlier studies, including Daggy's surveys, 97 species are presently known from Minnesota. The total number for the northern region should eventually number at least 140; southern areas will yield additional numbers.

Of the 54 species, 46 have strong geographic affinities with eastern Canada, and most of these also occur in north central and/or northeastern United States. A total of 41 of these species range into southeastern United States; within the southeast 20 appear restricted to Appalachian areas and 21 extend on to the coastal plain. Only six species, *Baetis macani bundyae, Cloeon simplex, Pseudocloeon anoka, Siphloplecton interlinatum, Stenacron can-*

didum, and *Stenacron minnetonka*, show no affinities with far eastern Canada. *Baetis m. bundyae* and *C. simplex* are Canadian species from north central and western regions, respectively; the other four species are primarily midwestern species.

Only four species from the study area remain unknown from Canada: *Callibaetis ferrugineus*, *Hexagenia bilineata*, *Stenacron minnetonka*, and *Stenonema integrum*. Another group of four species, *Baetis tricadatus*, *Caenis simulans*, *Ephemera simulans*, *Hexagenia limbata*, are widely distributed North American species that range even into southwestern United States.

New central states distributions are reported for *B. m. bundyae*, *Paraleptophlebia volitans*, and *Serratella serrata*. *Baetis m. bundyae* was previously known only from eastern Northwest Territories, Canada (Lehmkuhl, 1973; Cobb and Flannagan, 1980) and *S. serrata* was thought restricted to the Appalachians (Allen and Edmunds, 1963). Ranges are extended westward for *Eurylophella minimella*, *Eurylophella versimilis*, and *S. serrata* and northwestward for *Ephemerella needhami*.

Use of the dominant vegetative-growth forms as a predictor of species presence appears to function for some species (Scudder, 1979; Ross, 1963). The study area which is located in an ecotome between the coniferous and deciduous forests was expected to have faunal elements common to these forest types. Approximately 57% of the mayfly fauna were distributed within these forested areas. A large portion of the fauna (43%) is distributed beyond the boundaries of the dominant vegetative-growth form on to the southeastern coastal plain and southwestern regions of the United States, and even into the tundra of northern Canada.

Borders of drainage systems in northeastern Minnesota do not delinate distributional boundaries for mayflies and did not function effectively as a biogeographic barrier to dispersal. Only one species, *B. m. bundyae*, was restricted to the Hudson Bay drainage system and only five other species are known to be restricted to regions south of the Laurentian Divide at this time. These five species, *Eurylophella versimilis*, *Hexagenia bilineata*, *Pseudocloeon anoka*, *Stenacron minnetonka*, and *Stenonema integrum*, may occur to the north in Canada where few studies have been conducted.

The efficacy of the Laurentian Divide as a barrier to dispersal may have been circumvented while glaciers receded and waters that now flow north were continuous with southern river systems. This hypothesis has been suggested to explain some present day disjunct distributions of mayflies (Ide, 1955; Lehmkuhl, 1972, 1976) and other aquatic insects (Laufersweiler and Flannagan, 1981). The relatively short distance across the divide (Fig. 1) and the similarity of habitats on both sides undoubtedly increases the probability of successful aerial dispersal between drainage systems. Nevertheless, drainage system boundaries may be effective barriers to those species

restricted to large river environments since these species do not inhabit lower order streams near the boundaries.

Minnesota provides a good setting for the study of factors that may affect the distribution of aquatic insects since a number of distributional barriers and indicators converge within the state. The Mississippi River System, which drains much of central and all of southern regions of the state, borders the two northern drainage systems previously identified. Two major forest types (coniferous and deciduous) converge in the northeast. The prairie, which covers much of the south central and western sections, meet the deciduous forest along a diagonal line from the northwest to the southeast corners of the state. In addition some areas of the southeast are unglaciated. Perhaps future studies will develop a more complete understanding of the effects of climate, drainage system dynamics and glacial events of the present distribution of aquatic insects.

Since *B. m. bundyae* was found at a latitude much farther south than expected and in a distinctly different habitat, some biological notes are presented here on this species. In northern Canada this species inhabits edges of shallow tundra ponds (Lehmkuhl, 1973). In Minnesota larvae were found on wood, rock, sand, and detritus substrata in two first order streams. One stream flows among alder and tamarack [*Larix laricina* (Du Roi) K. Koch] and the other occurs in a cleared area; both are less than 1 m wide and about 0.1–0.3 m deep.

Specimens in the following stages of development were collected in 1977: two larvae with partially developed wing pads, 20 June (3.9–4.4 mm); four larvae with well developed but not darkened wing pads, 20 June (4.3–6.3 mm); two exuviae from mature larvae, 23 June (5.9–6.1 mm); one reared male, 23 June (6.2 mm); and one reared male, 29 June (6.4 mm). On 18 June 1981 five female larvae with well developed and darkened wing pads (6.5–7.0 mm) were collected. Mature larvae and adults in Canada are similar in size (5–7 mm and 5–6 mm, respectively) (Lehmkuhl, 1973; Morihara and McCafferty, 1979a). The temporal pattern of life cycles differ between northern and southern range extremes. In Canada larvae hatch in early July and adults emerge in early August (Lehmkuhl, 1973) while in Minnesota adults emerge in late June and larvae are presumed to hatch in May. *Baetis m. bundyae* is likely to have one generation per year and pass the winter in the egg state in Minnesota as in Canada since the streams it inhabits are reduced to pools in late summer and must surely completely freeze in winter.

Acknowledgments

We thank A. F. Bednarik, L. Berner, and D. K. Morihara for verifications of *Stenonema*, *Baetisca*, and *Baetis*, respectively. We appreciate the use of the late W. V. Balduf's data provided by L. Berner and thank E. F. Cook for archiving the study specimens. R. Hrdlick and P. Cleveland, The Insti-

tute of Paper Chemistry, assisted with the preparation of the figure and typing, respectively.

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